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Upgrading Traditional Technologies in Small-Scale Industry Clusters: Collaboration and Innovation Adoption in Indonesia

HENRY SANDEE and PIET RIETVELD

There is by now sufficient evidence that small-scale industry clusters matter in developing countries. This article intends to contribute to the discussion on cluster transformation by focusing on innovation adoption in a roof tile cluster in Indonesia. Clustering allows small-scale enterprises to grow in 'riskable steps' by sharing the costs and risks through collaboration. Using data from longitudinal field surveys we find that technological change is not only a matter of comparing costs and benefits of technologies, but also a matter of access. Collaboration among leaders is crucial in innovation adoption when technological indivisibilities play a role. In our case study it appears that joint action should be viewed as a means to an end only; it was given up in favour of traditional hierarchies in the cluster as soon as possible.

INTRODUCTION

Recently, there has been an upsurge of interest in clustering as a possible strategy for small-scale enterprises to 'stay on board' in the process of industrialisation and economic development. There is increasing evidence that small-scale industry clusters matter in developing countries [*Schmitz and Nadvi, 1999*]. This is also true for Indonesia. Klapwijk [*1997*], while using a definition of a cluster as a group of at least five industrial enterprises belonging to the same subsector in a village, estimates for the Indonesian province of Central Java that there were some 4,400 clusters by 1989. Together, these clusters contain some 675,000 workers which is some 30 per cent of total manufacturing employment. In the literature attention is shifting towards cluster dynamics, and a main issue is whether there are

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possibilities for the many dormant clusters to transform into more vibrant entities. Some authors have used the concept 'trajectory of cluster development' to address cluster dynamics [*Humphrey, 1995a*, *1995b; Knorringa, 1997*].[1] Schmitz and Nadvi [*1999*] argue that clustering allows small-scale enterprises to grow in riskable steps through collaboration. Small amounts of capital, skills and entrepreneurial talents can be made to count when producers work together. In this article, we intend to contribute to the discussion on cluster dynamics by focusing on innovation adoption which allows enterprises to make better products that can be sold to higher income market segments. Our study illustrates that cluster development may imply that the local entrepreneurs move beyond passive enjoyment of external economies of scale in clusters towards intensive interfirm collaboration. We argue also that such collaboration should be viewed as a means to an end only, and small-scale entrepreneurs view it as a strategy to share the costs and risks associated with technological change. We concentrate on the transformation of relationships within a cluster as a result of the innovation process.

This article concentrates on the roof tile subsector in Central Java, Indonesia. We are interested in a specific phase of the trajectory of development, namely innovation adoption in traditional clusters. In our case, upgrading traditional tile production methods implies the adoption of so-called indivisible technology which, at the early stages of the transformation process, cannot be profitably run by individual producers but require collaboration. Our study will show that specific forms of collaboration will last as long as it is functional for leading actors.

Section I of this article discusses a framework to assess transformation of clustered enterprise. Section II introduces the roof tile subsector in Central Java. We introduce the specific phase of the trajectory of development in this subsector which has our concern, namely the upgrading of traditional production technologies. Our case study, regarding the innovation adoption in the cluster *Karanggeneng*, is discussed in sections III to VIII. We present the production and marketing systems with particular attention for interfirm collaboration prior, during, and after the introduction of new production technology in the cluster.[2]

I. COLLABORATION, TECHNOLOGICAL CHANGE AND CLUSTERED ENTERPRISE

Small-scale producers in clusters may profit from the proximity of colleagues. Information may be shared, there are possibilities to purchase inputs together, visiting traders may buy from several producers simultaneously, etc. Collaboration among producers may occur also when

there are sudden cash shortages or when there are rush orders that need additional labour at short notice [*Sandee, 1994*; *Schmitz, 1995*]. Such collaboration is often not confined to economic relations only, and it may encompass also social relations. This is most likely to be the case in rural industry clusters. Extended family networks are especially important when small-scale enterprises are all located in specific hamlets where certain families have been living for generations [*Weijland, 1999*]. Collaboration is based on both economic calculations and social obligations, and producers may take decisions that appear to be not in their short-term interest, but which pay off at a later stage.

The majority of small enterprise clusters in developing countries are dormant clusters which produce basic products for poor consumers. Clustering does not seem to bring many external economies in the dormant clusters as most household enterprises operate independently of other enterprises. Clustering may simply occur because certain bulky resources are available at certain locations only. It may also be to the advantage of buyers as there are likely to be transaction cost reductions if they can purchase the products at one location only [*Klapwijk, 1997*]. Technological change is essential for the development of dormant clusters. After all, innovation adoption will lead to improved or new output which may be sold to more dynamic markets. It is argued that technological change requires more than the general forms of collaboration discussed above [*Sandee, 1995*]. Technological change may require more explicit collaboration with small producers working together 'for specific purposes' [*Schmitz, 1997: 10*]. Schmitz and Nadvi [*1999: 1504*] formulate the importance of collaboration for cluster development as follows: ' … external economies are not sufficient to explain cluster development. In addition to incidental external economies, there is often a deliberate force at work, namely the conscious pursuit of joint action.'

An important constraint to the development of small-scale enterprises is the existence of technological indivisibilities that inhibit innovation adoption. This refers to equipment and machinery that are an indispensable part of the new technological package but which cannot be adopted profitably by individual small firms. Clustered enterprise is better able to adopt such equipment and machinery than dispersed enterprise because small producers are in a position to collaborate [*Sandee, 1995*]. Collaboration of this type is frequently based on precise economic arrangements worked out among the participants, such as sharing the costs and benefits of technological indivisibilities. It may well differ from the more traditional forms of collaboration that are based on extended family networks. The 'new' forms of collaboration serve specific purposes, like rendering innovation adoption successful, and they may last as long as they are functional [*Knorringa, 1996; Schmitz, 1997*]. In the case study below,

we discuss how different forms of collaboration each have a purpose in the process of innovation adoption and diffusion in technological upgrading in a roof tile cluster.

II. THE ROOF TILE SUBSECTOR IN CENTRAL JAVA, INDONESIA

Various types of production technologies and clusters may be distinguished in the roof tile subsector of Central Java. Table 1 presents the main characteristics of four different production technologies for clay tile production. Open-fire and kiln production are traditional technologies; they have been present in Central Java since the beginning of the last century. In open-fire production, preparing clay is done through feet pounding; printing is done with the aid of a simple wooden mould; then printed tiles are put on a heap, covered with rice husks and wood, and fired. Kiln production also makes use of hand pounding, while better moulds are used for printing. The main difference is that a kiln is used for firing tiles. Compared with open-fire production, the kiln technology is characterised by a stricter division of labour within the enterprise and also between enterprises and suppliers of inputs and services. Open-fire production relies fully on family labour, which is flexibly used to perform the various tasks. Kiln production makes use of both family and paid labour in the production process; there is a clear division of tasks with paid workers mainly involved in printing.

The main difference between traditional and mechanised tile production is that in the latter case printing tiles is done with presses instead of wooden moulds, which leads to higher quality output. The handpress technology is an updated version of the traditional kiln technology using simple presses to arrive at better quality output. Pressing such tiles requires a better clay mixture, which is obtained through the introduction of a diesel-driven clay mixer.

TABLE 1
CHARACTERISTICS OF THE RURAL TILES SUBSECTOR IN CENTRAL JAVA ACCORDING TO TECHNOLOGY

Technology	Open fire	Kiln	Hand press	Power press
Size of enterprise	Household	Micro	Small	Medium
Interfirm linkages	Underdeveloped	Underdeveloped	Developed	Disintegrated
Marketing	Producers	Producers, intermediaries	Intermediaries, wholesalers	Wholesalers
Markets	Poor rural consumers	Rural and poor urban consumers	Middle income urban consumers	Middle and high income urban consumers
Relative importance in subsector employment generation	53 %	22 %	15 %	10 %

Source: Own surveys.

In this article we concentrate on transformation through innovation adoption by traditional clustered enterprise with kiln technology through introduction of the handpress technology. In the case of traditional kiln production, clustering makes it feasible for individual producers to accept orders which exceed their own production capacity. It facilitates out contracting of work to relatives and neighbours, so that deadlines can still be met. In the case of press tile technologies there are additional advantages associated with clustering. These are particularly relevant for clustered enterprise with handpress technology. Handpress production requires access to clay mixers which are, at Rupiah 2.5 million in the early 1990s, too expensive for purchase by individual adopters.

III. TRADITIONAL TILE PRODUCTION IN 1987 (THE BASELINE)

The tile cluster of Karanggeneng is located on the outskirts of Boyolali town, which has a population of about 60,000 inhabitants and is the only urban centre in the Boyolali regency. The tile cluster has some 120 producers, and it is situated very close to the main road which links the big cities of Solo and Semarang in Central Java. In 1987, tiles from *Karanggeneng* were known as the best-quality traditional output from the Boyolali regency. Thanks to good transport facilities, the Karanggeneng producers have access to a wide market, compared with surrounding clusters. Transport of tiles is taken care of by the many trucks which operate between the main cities of Java.

(a) Tile Production and Marketing Chains

Table 2 provides insight into the distinct production-marketing chains through which traditional tiles are marketed. The majority of producers do not sell directly to final consumers. They sell to middlemen, or receive their orders from other producers in the cluster. Their production sites are located off the main village roads. Purchase of inputs and selling output are not their responsibility. There are also producers who sell directly to consumers. They take care themselves of the transport of tiles to customers while using the intermediary services of visiting truck drivers who are looking for work. Table 2 presents a comparison of tile producers selling their tiles through different chains. The table shows that producers selling directly to consumers do not only sell more tiles than the others but also sell tiles at higher prices. This is understandable because the bargaining position of individual consumers is, of course, not as strong as that of professional middlemen and owners of building material shops. The characteristics of these producers show that they have invested more in their business. These producers are also older than the others.

TABLE 2

COMPARISON OF TILE PRODUCERS PRODUCTION AND MARKETING CHAINS IN KARANGGENENG, DRY SEASON 1987

	Sales to Intermediaries (n=23)	Direct Sales to Customers (n=11)	All Producers (n=34)
Tiles Output (number)	62,400	67,100	63,900
Average Price of Tiles (Rp.)20.4	29.5	23.3	
Family and Household Characteristics			
Access to Land (ha.)	0.13	0.12	0.12
Seasonal Household Income (Rp.'000)	572.0	1,204.7	752.9
Characteristics of the Enterprise			
Industrial Capital (Rp.'000)	264.6	659.7	392.4
Age of Entrepreneur (years)	32.0	47.8	38.8
Ownership of kiln (%)	70.4	88.1	77.6

Source: Own survey.

(b) Collaboration and Extended Families

Clustering of tile enterprises in Karanggeneng allows co-operation in the execution of large construction projects, such as the production of tiles for market shelters. Out contracting is, in such cases, very common among tile enterprises in Karanggeneng, especially among producers belonging to the same extended family or social group. With such large families or groups, trust among producers is high. Moreover, it is easy to execute subtle forms of pressure within families or groups, to ensure that subcontractors will perform in accordance with requirements. In Karanggeneng, family ties are important and most producers can easily point out a number of relatives who are also involved in tile production. Successful producers are expected to share some of their benefits with their less successful relatives. This is also in their interest, because, when needed, it provides 'standby capacity'. As a result, they can accept orders which exceed their own capacity and they can expand their production through the involvement of other producers in their network. There is frequent exchange of workers among enterprises belonging to the same extended family. Relatives may also be an important source of finance for working capital. Leaders provide advice on quality of output, and they offer apprenticeship to their extended family. Collaboration in traditional tile production is important because it gives small household enterprises the capacity to adjust flexibly to changes in demand.

There is strong participation of women in traditional tile production. In most cases, women of the household participate in the family tile business, at least on a part-time basis. In addition, there are also paid female workers

who are recruited to assist in printing tiles. There is a rather strict division of labour within the enterprises in Karanggeneng. Women are chiefly responsible for printing, while males are predominant in the other stages of the production process. There is a limited number of female producers producing traditional tiles. Most of them have lost their husband but continue to run the enterprise. Some of them carry out the tile business while their husbands have migrated to towns in search of better paid jobs. There are plenty cases in the tile cluster of female producers who run their traditional tile business efficiently and whose incomes do not differ substantially from their male counterparts.

IV. DIVERSITY AMONG EARLY ADOPTERS

When we now look back, we can conclude that the conditions for technological change in Karanggeneng were satisfied. The market environment for pressed tiles was promising, and producers were aware that the new product was in great demand. The economic situation in Indonesia in the period 1986–97 was characterised by substantial increases of annual income, especially in urban areas. Demand for upgrading existing dwellings and constructing new ones was particularly high, and this resulted in a rapid growth in demand for better quality construction materials such as pressed roof tiles. It seems that the time was right for the introduction of pressed tile production in the Boyolali regency, in which Karanggeneng is situated, to fulfil the growth of regional demand.

Innovation adoption does not come about by itself. Technological change needs actors who take initiatives leading to pioneer adoption by certain entrepreneurs. In the case of Karanggeneng, pioneer adoption was initiated by a young entrepreneur from a family with long-term involvement in tile production. He was a university drop out who had travelled widely and worked in the big cities of Semarang and Jakarta. For him, innovation was a challenge which was supported by the extended family. In spite of his age, he was already well established as a traditional tile producer.

Successful innovation adoption requires that pioneer adopters are able to bridge the technical, financial, and markets gaps associated with technological change. Information on the press technology was obtained through a government assistance programme. It took a trip cofinanced by producers, local government and a university to give several Karanggeneng producers an opportunity to actually see the handpress technology with their own eyes, and assess together whether they were technically and financially able to adopt it as well. Joint trips by producers to urban-based building materials shops provided pioneer adopters with orders for press tiles, and it convinced them that it was worth taking the risks associated with technological change.

(a) Characteristics of Early Adopters

Our first survey in 1987 included a section in which the producers were asked to look at the future and forecast how their tile business would develop. It is interesting that none of them mentioned that they planned to adopt the handpress technology. Our second survey of the panel group was carried out in the dry season of 1990. Although most producers continued to produce traditional tiles only, there were some who had innovated and there were some who had stopped producing tiles altogether.

Table 3 summarises the different developments in the cluster. The majority of producers in 1990 were still producing and selling traditional tiles only. Adopters were still also involved in traditional production. The table shows that there were five producers who were no longer manufacturing tiles in 1990. Traditional tile prices rose from Rupiah 23.3 in 1987 to Rupiah 35.2 in 1990.[3] The prices of both clay collection and, especially, firewood rose significantly in this period. Moreover, the panel sold fewer traditional tiles, compared with three years previously. Table 3 shows that the decrease in traditional output is explained by the partial shift of certain producers to pressed tiles as well as the exit of some producers from tile production

(b) Traditional Producers

In 1990, the majority of the producers were still exclusively producing traditional tiles, which were sold through the same production and marketing chains as in 1987.[4] Table 3 showed that they produced slightly more tiles during the dry season, compared with three years earlier. In Table 4, we compare traditional tile producers operating in different chains.

TABLE 3

DEVELOPMENTS IN THE GROUP OF TILE PRODUCERS IN KARANGGENENG, 1987, 1990

	1987 Traditional Tiles		1990 Traditional Tiles		1990 Pressed Tiles	
Type of Development	Output ('000)	Price (Rp)	Output ('000)	Price (Rp)	Output ('000)	Price (Rp)
Production remains traditional (N=25)	67.2	21.7	69.5	35.1	–	–
Partial shift to pressed tiles (N=4)	71.4	26.7	21.6	36.0	57.3	55.0
Production is stopped (N=5)	58.8	25.6	–	–	–	–
All enterprises (N=34)	65.3	23.3	53.7	35.2	6.7	55.0

Source: Own survey.

TABLE 4

COMPARISON OF TRADITIONAL TILE PRODUCERS PRODUCTION AND MARKETING CHAINS IN KARANGGENENG, DRY SEASON 1990

	Sales to Intermediaries (n=19)	Direct Sales to Customers (n=6)	All Producers (n=25)
Tiles Output (number)	67,500	75,800	69,500
Average Price of Tiles (Rp.)	32.5	42.4	35.1

Source: Own survey.

The table shows that both groups of producers sell more than in 1987; they produce more batches and use their workforce more hours a day and also more days a season. This growth of output has generally not resulted in an increase in the size of the workforce. The differences between the performance of traditional producers belonging to distinct trade production-marketing chains remain substantial, and producers with direct access to markets sold more traditional tiles and at higher prices than others.

(c) Quitting Traditional Tile Production

We saw in Table 3 that a number of producers were no longer involved in tile production in 1990. There are various reasons for quitting. Some went bankrupt and left the village; others became wage workers for other tile producers. There are also examples where quitting tile production is a sign of upward mobility, such as the case where a household was able to get access to a relatively well-paid job in the formal sector. Abandoned sites were mostly rented out to others, who could be either newcomers or existing producers, but who were always part of the extended family of those who quitted.

(d) Early Adopters in the Panel Group

In 1990 there were 32 adopters in Karanggeneng. Adopters are underrepresented in our panel group. Four producers of this group had adopted the handpress technology by the time of our second survey in 1990. They were not, as will be discussed below, among the pioneer adopters in Karanggeneng. Two of them can be classified as 'typical forerunners' in processes of technological change. They have direct access to markets and resources and possess the necessary skills. Their early adoption confirms the theory that focuses on adoption as a decision-making process by individuals. Here, factors such as education, skills, entrepreneurship, access to resources and capital, and so on, are viewed as crucial factors in the timing of adoption by individual producers. There are, however, also two

adopters who have very different characteristics. They sell their tiles to other producers and they do not have direct access to markets. Furthermore, these producers have rather weak entrepreneurial capabilities, since they have never been exposed to direct trade with buyers. In addition, they are highly dependent financially on leading producers, who provide them with advance payments and who specify the orders. We cannot understand the nature of the innovation adoption process in the cluster while solely relying on this panel group. It is necessary to go beyond these randomly selected producers and focus on the networks and collaboration between producers which become visible when we concentrate on the adoption process.

V. EARLY ADOPTION, COLLABORATION AND INDIVISIBILITIES

There were three pioneer adopters in Karanggeneng. The pioneers had all joined the government-sponsored trip that gave the producers an opportunity to see and assess the feasibility of the handpress technology. Traditionally, they were leading producers in the cluster; they have direct access to markets and they are frequently contracting out orders to their 'followers'. The first one is a young, ambitious university drop out. Two others are experienced producers who are important persons in their extended families. All three pioneers financed the purchase of the handpress out of their own funds. As mentioned above, an essential (and most expensive) element of the handpress technology is the motorised clay mixer. Since one mixer can be used in combination with about six handpresses an indivisibility problem emerges in the first phase of adoption. This was solved by the young entrepreneur, who bought the clay mixer after receiving assurance from the other pioneers that they would buy presses and use the services of his mixer.

Relations among these three pioneers were mutually beneficial and based on economic calculations: orders for pressed tiles were shared, the mixer was used in turns, and the new output was promoted jointly. The pioneers received assistance from manufacturers of press equipment, who spotted new market opportunities. The first presses were bought at relatively low prices and on credit from these suppliers. Pioneers also co-operated to create a supportive infrastructure, including credit for working capital and repair services, which are necessary due to the lack of support from outside.

During the early stages of innovation, adopters did not want to lose their access to the market for traditional tiles, because they might need to fully return to production of traditional tiles if the adoption of the handpress technology is not successful. The cluster context offers very good possibilities for adopting and concentrating on pressed tile production,

while keeping access to traditional tile markets through contracting out orders. This points to an advantage which clustered enterprise has over dispersed enterprise. In the latter case, adoption may very soon call for a decision as to whether it is possible to combine traditional with new forms of production. The specific nature of tile production, where clustering allows simultaneous involvement in traditional and press tile production, facilitates the speed of innovation adoption because pioneers do not necessarily loose access to their traditional market outlets as these can be maintained through contracting out work.

VI. INNOVATION ADOPTION AND DIFFUSION BY 1990

By October 1990, there were 32 adopters in the cluster who together controlled 39 presses. An increasing number of adopters decided to stop manufacturing traditional tiles altogether. Although orders for traditional tiles are still accepted, most jobs are contracted out. Table 5 compares the characteristics of traditional producers and adopters in 1990.

The important role of pioneer adopters becomes clear when we examine how presses are actually bought, how adopters learn to master the new technical skills, how they gain access to mixers, and especially how they market their new output. The majority (80 per cent) of the early adopters did not buy the press themselves. They placed their order with one of the pioneers. It is the young pioneer who ordered large numbers of presses simultaneously, and the adopters paid him and not the suppliers directly.

TABLE 5

COMPARISON BETWEEN TRADITIONAL AND PRESS PRODUCERS IN KARANGGENENG IN 1990

	Traditional Producers (N=25)	Adopters (N=32)
Age Entrepreneur (years)	43.1	36.4
Tiles Output (thousands)		
Traditional	69.5	18.4
Pressed	60.4	
Tiles Prices (*Rupiah)*		
Traditional	35.1	36.4
Pressed	58.2	
Industrial Capital (*Rupiah* '000)	264.6	1,350.8
Household Income (*Rupiah* '000)	980.7	1,532.4

Source: Own survey.

The same group of adopters also relied on this pioneer for learning the technical skills. By 1990, there were four mixers in Karanggeneng. A first one is shared by two pioneers and a group of early adopters. Two mixers are owned by the young pioneer, while another mixer is managed by a non – governmental organisation (NGO) which has set up a project in the cluster.

An important development is that the young pioneer is no longer collaborating with other pioneers, but is heading his own network again. By 1990, this network was already the largest in the cluster, and it is, in fact, an 'upgrading' of his traditional network discussed above. One of the reasons for the upgrading of the traditional network is that it has allowed the pioneer to achieve higher profits than would be possible through continued joint production with other pioneers. Another important reason for upgrading, however, is the emergence of social pressures from the extended family to share the higher benefits of press tile production with relatives.

Pioneers take an active interest in stimulating adoption by others in the cluster. There are several reasons for this. The first reason is associated with the joint use of the mixer. The services of the mixer are not provided free of charge. The costs for mixing clay for a regular production cycle were Rupiah 9,000. The job is done by specialised workers who are on the pay list of the owners of the mixer. Owners of mixers, among whom is the young pioneer, are highly motivated to stimulate diffusion, because this will increase demand for services of mixers. A second reason is related to the reluctance of traders and others to market pressed tiles from Karanggeneng during the period 1987–90. This implies the emergence of opportunities for local entrepreneurs to market pressed tile output. Commissions are charged by pioneers for marketing tiles manufactured by others. A third reason is related to technical assistance which is needed to operate the press technology. Such assistance is not required when press equipment is first installed, but there is a need for technical assistance at later stages when the producers want to standardise and improve the quality of output. In Karanggeneng, technical assistance in the period around 1990 was almost exclusively provided by the young pioneer and it was linked to the purchase of the press machine. If the press was not bought from the young pioneer, it became very difficult to rely on him for technical assistance. Finally, a fourth reason is that the lack of access to funding for the new technology also offers possibilities for local entrepreneurs to engage in new business opportunities. Pioneer adopters, especially the young pioneer, provide credit on a large scale to producers who are interested in buying the press technology. They have access to formal credit which they informally lend out to producers who join their network.

VII. FURTHER DIFFUSION OF HANDPRESS TECHNOLOGY

The cluster Karanggeneng was regularly mentioned in the regional newspapers during the period 1990–93. Problems regarding the negative environmental impact of tile manufacturing were solved, because the local government allocated new land for clay digging. Urban expansion of nearby Boyolali city has resulted in a diversion of heavy traffic which is no longer allowed to pass through its main street. Instead, the traffic passes through Karanggeneng, and this makes the cluster much more accessible to buyers. Both developments have stimulated further adoption of handpress technology. There were 50 adopters by the time of our final fieldwork in 1993. The annual number of adopters levelled off in 1992 and 1993. There were still slightly over 50 percent of the adopters who had not innovated by 1993. This raises the questions of why they have not yet adopted and under what conditions they are likely to do so in the future. Again, a network approach and insight into inter-firm collaboration patterns are needed to address these questions.

(a) Explaining Innovation Adoption

We will now analyse innovation adoption by means of two data sets. First, we have access to a full census executed in 1993, which covers all traditional and pressed tile producers.[5] Secondly, we have data derived from monitoring our panel group of producers, which was carried out for the third time in 1993. We have carried out logit regression analysis with both census data and panel monitoring data to analyse the variables affecting adoption. The census data provide an insight into characteristics of individual producers because they were collected over a short period of time, and they lack the depth of analysis of the panel data that concern a selected group of producers that were followed throughout the years. The latter data set is more explicit concerning the networks and collaboration patterns among producers.[6]

Table 6 presents the results for the (logit) regression analysis using the census which allow us to analyse adoption using data on individual producers and their households. Age of the entrepreneur is selected as a variable, because we expect that older producers may be better able to bear the risks and costs associated with innovation adoption. Age brings experience in dealings with the market and new products that may be useful when it comes to adopting the press technology. Education is another variable taken into consideration. Higher education may be an asset for innovation adoption for various reasons. It may facilitate the accessibility of small producers to information on new production processes, products, and markets. Further it may have a positive impact on the willingness of

TABLE 6

LOGIT REGRESSION ANALYSIS FOR ADOPTION, FULL MODEL AND SELECTED VARIABLES, DRY SEASON 1993 (N=103) CENSUS DATA

Variable	Specification 1 Coefficient	(t-value)	Specification 2 Coefficient	(t-value)
Age entrepreneur (years)	–0.01	(–0.14)		
Education (years)	0.6	(2.58)*	0.47	(4.08)*
Access to land (ha)	2.51	(1.10)		
Gender (dummy)[7]	3.01	(2.58)*	2.80	(2.54)*
Constant	–4.86	(–2.34)*	–4.70	(–3.93)*
Log likelihood	–47.03		–47.04	

*Significant at 5 % level

Source: Own fieldwork.

producers to take risks. Education may, for example, indicate the extent to which producers master the national language bahasa Indonesia, which is an asset in trade negotiations and also important when producers intend to apply for loans. Another variable, access to land, was added to analyse whether innovation adoption is influenced by the degree to which tile producers and their families are still involved in agricultural production. We expect that a strong involvement in agriculture will not have a positive influence on innovation adoption in tile production, because the households will have to spread their resources over various income-generating activities. Tile production may not be considered as the main job of the household that deserves full attention. Finally, we considered also the importance of gender to explain innovation adoption, as there are substantial numbers of female entrepreneurs among the traditional producers in the cluster.

Table 6 shows that the education and gender of the producers are the important variables. Up to 1993, there were no female adopters in the cluster, although it is common to find female tile producers – often from female-headed households. We will return to the specific constraints on adoption for female producers further on in this article. We see in Table 6 that age of entrepreneur cannot explain adoption by 1993 when almost 50 per cent of the cluster has innovated. It is not, therefore, true that the senior producers who have secured strong positions and production and marketing chains throughout the years adopt earlier than their junior counterparts. Also access to land appears not to be relevant with some land-rich families being able to invest their income from agriculture in the upgrading of their tile business, while others are more interested in expanding their involvement in farming rather than diversifying their sources of income.

(b) The Importance of Networks and Collaboration

Our panel group survey allows us to assess the importance of networks and collaboration while explaining adoption of innovations. Our monitoring of the panel group allowed us to get better insight into networks and collaboration than a one-shot survey research. In particular, we have looked into the importance of collaboration among producers and trade networks. Regarding inter-firm collaboration we expect that family networks matter when it comes to innovation adoption. Relatives of pioneer adopters are expected to be in a relatively favourable position to innovate, because pioneer adopters may feel more comfortable with turning to relatives than others to stimulate innovation diffusion in the cluster.[8] We discussed above that middlemen have not been important actors in technological change processes in the clusters, and that they remain trading traditional tiles only. Therefore, we expect that producers that market mainly through middlemen will not feature prominently among adopters. Another potentially relevant factor is firm size prior to the innovation period. Successful traditional producers are expected to find it easier to deal with the risks of innovation than others. We used the enterprise output level in 1987 as indicator of size of enterprise before the process of technological change begun in Karanggeneng.

TABLE 7

LOGIT REGRESSION ANALYSIS FOR ADOPTION, FULL MODEL AND SELECTED VARIABLES, DRY SEASON 1993 (N=29) PANEL GROUP DATA

Variable	Specification 1 Coefficient	(t-value)	Specification 2 Coefficient	(t-value)
Age entrepreneur (years)	–0.05	(–0.47)		
Education (years)	1.93	(1.84)	1.66	(2.12)
Gender (dummy)[9]	3.01	(0.85)		
Social network (dummy)[10]	4.30	(1.92)*	4.35	(2.98)*
Middlemen network (dummy)[11]	–3.21	(–2.45)*	–3.42	(–2.78)*
Output 1987	–15.05	(–1.51)	–11.46	(–2.19)
Constant	–0.01	(–1.41)		
Log likelihood		–6.51		–6.62

*Significance at 5 % level

Source: Own fieldwork.

We have tested the expectations formulated above by a logit regression analysis with the survey data of the panel group. The results are presented in Table 7. Once more the aim is to explain why certain producers adopt while others continue to produce traditional tiles. We could only trace 29 enterprises of the original panel group.[12] The regression analysis was carried

out first with all variables, and then with selected variables only. The results confirm to some extent the findings of the logit analysis with survey data presented in Table 6. Education matters once more when it comes to innovation adoption. We now see, however, that the social network in which producers operate is also of importance. Adoption is facilitated if there is a family relationship with a pioneer adopter. Table 7 also indicates that producers who sell exclusively to middlemen are in a disadvantageous position with regard to innovation adoption. Middlemen link the producers in Karanggeneng to rural households, who show little interest in buying pressed tiles. In the other production and marketing chains, there are better possibilities for participation in pressed tile networks, especially for those who are relatives of the young pioneer. With this small number of observations, no significant impact could be found for gender. Interestingly enough, the coefficient for output in 1987 is negative: in this cluster, the introduction of the innovation has led to a rather different distribution of income among producers.

Table 7 points to the importance of interfirm linkages and collaboration for explaining adoption. Adoption is not merely an individual choice of producers that depends on their physical and human resource endowments, their access to finance, and so on. Adoption is also dependent on incentives, pressures, and constraints that producers face in the social network in which they operate. It is, therefore, not only a matter of being able to adopt but also whether they are 'invited' to adopt by leading producers in the cluster. Ellison and Fudenberg [*1993*] argue that economic agents, such as tile producers, may base their innovation adoption decision on the experiences of neighbours. They observe their neighbour's choices and the pay offs that these generate. Such observation is indeed facilitated when producers have the opportunity to learn from neighbours (who have adopted) with whom they have much in common, or who, in other words, are their peers. The case of tile production in Karanggeneng suggests that additional mechanisms play a role. We found that the social networks in which producers operate are important for explaining innovation adoption. Our findings suggest that producers not only learn from observing adopters, but may also become motivated to adopt by their network leaders.

We note that the collaboration among pioneer adopters did gradually fade away in favour of the re-emergence of traditional forms of cooperation which are structured around kinship networks. We have discussed above that the former were clearly mutually beneficial to adopt new technology by 'riskable steps'. All pioneer adopters profited from collaboration to overcome the problems associated with the technological indivisibilities of innovation adoption. These forms of collaboration

should be viewed as a means to an end only. Once the risks and uncertainties of technological change were reduced, there was an upgrading of traditional production and marketing patterns which incorporated the new production technology. We see however that adopters are keen to revitalise traditional networks as soon as possible because of both economic calculations and social obligations. Their new pressed tile networks are favourable for all participants, but most advantages accrue to the network leaders. Also, through their control over demand, they remain also key actors in the production and marketing of traditional tiles. In 1993, there were 24 press producers and five traditional producers that were dependent on the young pioneer for marketing, technical and financial assistance, and services (including use of the mixer). There are also a number of other networks headed by other pioneers and also by an NGO and a middleman. The scale and scope of these networks does not permit their leaders to provide assistance and services similar to those provided by the young pioneer. For example, if the press machine breaks down, the network has to call on services from outsiders, which increases the costs. Production and marketing chains tend to specialise increasingly, with each chain concentrating on a particular type of tile.

(c) Comparison of Traditional and Press Tile Producers

Table 8 compares economic characteristics of the traditional and pressed tile producers in 1993. Adoption of handpress technology leads to an important growth of turnover and an almost 100 per cent increase in the workforce. There were still 53 traditional producers in the cluster, of whom some 45 per cent were females. The table shows that press producers have received more education, but that they do not differ substantially from others in terms of

TABLE 8

COMPARISON OF TRADITIONAL AND PRESSED TILE PRODUCERS, CENSUS DATA 1993

	Traditional Producers			Press Producers
	Male N=29	Female N=24	All N=53	N=49
Average turnover (Rupiah '000)	2,116.20	1,781.90	1,880.90	9,184.30
Age entrepreneur (years)	48.50	44.80	46.80	44.00
Access to land (ha.)	0.06	0.08	0.07	0.06
Education (years)	3.30	2.20	3.00	6.20
Total Paid and Unpaid Employment (persons)	3.40	3.10	3.20	6.00

Source: Own survey.

age and access to agricultural land. There were no female adopters of handpress technology. This is a remarkable result since female entrepreneurs are prominent among the traditional producers.

In Table 8, we make a distinction between male and female traditional producers. The latter have a lower turnover in 1993 and employ slightly fewer (paid and unpaid) workers. Press producers may no longer manufacture traditional tiles, but they are still contacted by a large number of (institutional) customers who want to buy these tiles from them. The jobs, however, are contracted out, especially to female relatives who have become their subcontractors for traditional tiles. Thus collaboration takes also new forms with leading press producers playing a key role in the development of traditional tile producers through subcontracting relationships.

(d) Constraints on Adoption

Constraints on adoption are particularly felt by female tile producers in Karanggeneng. By 1993, no female entrepreneur had adopted the press technology. Access to networks and dissemination of information on the new production technique is limited to men. Moreover, women have very limited possibilities for developing their own network, since they have no access to formal credit to finance adoption and cannot rely on money lenders because the latter concentrate on male producers. Women are also much less informed about the characteristics of the new technology, because little information is disseminated to them. More generally, female producers are confronted with norms regarding production and technological change which do not stimulate adoption [*Wahjana, 1994; Van Velzen, 1994*]. Such effective exclusion mechanisms appear to apply also to specific groups of male producers. Many producers in these groups report that they are interested in innovating but cannot afford it. They lack the means to finance technological change themselves. These producers in both groups are embedded in the networks of local leaders, but have the exclusive task of producing traditional tiles. The Karanggeneng cluster remains an important centre for traditional tiles, which makes network leaders reluctant to stimulate further innovation diffusion. Press tile production leads to higher profit margins, but there remains uncertainty about the future during the first years of introduction of new technology. It is considered wise not to switch one's networks fully to press tile production at this stage.

VIII. THE ROLE OF INSTITUTIONAL SUPPORT

An important initiative in which the local government participated was the organisation of 'study tours' to clusters where the handpress technology was

widespread. The tours were important, because they improved access to information, both for producers and also, importantly, for suppliers of capital goods, who saw possibilities for penetrating the Karanggeneng market. It has also contributed to joint exposure of selected producers who were to play key roles in pioneer adoption. The process of pioneer adoption diffusion has occurred without any training, technical assistance, or involvement in government credit schemes. In more recent years, support increased after the adopters had proved that pressed tile production was viable. An NGO developed a rotating savings- and credit fund to stimulate collaboration and further adoption. This fund was particularly popular among network leaders who used the funds to finance innovation adoption of specific followers.

The government has chiefly provided indirect support which has played an important role in sustaining technological change in the tile cluster. It stimulated the use of pressed tiles from Karanggeneng in regional construction projects. Finally, but very importantly, the urban expansion plans of the city of Boyolali were revised and no longer posed a threat to the existence of the tile cluster. Government support has speeded up a process of producer-driven innovation which was already in progress. The support has been effective in improving the pressed tile producers' access to nearby markets. At a later stage, the Industrial Office in this regency has haphazardly encouraged local banks to provide credit to producers once urban expansion plans did no longer clash with the development of the tile cluster. Not surprisingly, its direct support was aimed at local pioneer adopters: they were encouraged to apply for loans from the banks. This support has contributed to strengthening and upgrading of traditional networks. The government assistance efforts were not aimed purposely at strengthening collaboration among small-scale producers in the cluster. However, both technical and financial assistance were geared at local leaders who have profited from support to develop their networks and inter-firm collaboration.

IX. CONCLUSIONS

The tile cluster in Karanggeneng shows that the fact that small firms are clustered is not only good for their efficiency in a static context, but also in a dynamic context: clustering provides crucial advantages when innovations adoption implies the introduction of technology with large indivisibilities. Clustering makes is possible to adopt such new technology packages in 'riskable' steps through sharing costs and risks. Successful pioneer adoption in this tile cluster is explained primarily by two factors. First, traditionally leading producers got access to

information on more productive technologies. They knew about pressed tiles but had not had the opportunity to 'see and feel' the equipment with which those tiles are made. Intermediaries have played a crucial role in providing producers access to information by bringing them to press tile clusters. Here they could get answers to questions such as: how does the new equipment actually work, what are its costs of production, how many workers are needed, what about their skill levels, what are the consumer tastes with respect to press tiles, etc.? Small-scale producers often do not have access to such crucial information which provides the right framework to assess innovation adoption. Second, leading producers were able to step out of their traditional networks and develop joint action together with their competitors. They managed to transcend traditional boundaries and practices in order to collaborate and render innovation adoption profitable. Joint action to foster technological change worked because local leaders saw clear economic advantages. Technological change in the cluster shows that small producers may work together successfully 'for specific purposes'.

Our study shows that collaboration among leaders was given up in favour of re-emergence of traditional hierarchies as soon as access to information was no longer a constraint and its economic advantages disappeared. Technological indivisibilities were incorporated into old networks and hierarchies as soon as this became possible. Our study also shows that innovation adoption is not only a matter of individual producers comparing costs and benefits of technologies, but also a matter of access. There are clear indications that certain producers are not allowed access to the new technology by the leaders of the cluster. This holds true especially for women producers. A possible background may be that the leaders want to limit the supply of new products in an effort to keep the prices at an attractive level.

We find that support agencies may enhance the effectiveness of their programmes by focusing on key issues such as access to information and joint action. Access to information can be improved through inviting producers to visit exhibitions, production centres, clusters, markets, etc. Here they can complete their picture on new technologies and assess whether these are within their reach. In addition, support agencies may stimulate producers and intermediaries to work together and do things collectively and create synergies.

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NOTES

1. This article is based on research done in the framework of the Ph.D. study of Henry Sandee on innovation adoption in rural industry [*Sandee, 1995*].
2. We are aware that in part of the innovation literature the concept of trajectory is used in a more specific and limited way: 'A technological trajectory starts with a discovery or an idea. Fundamental research will lead to the discovery being recognised as an invention. Proving the technological feasibility of the technique will lead to the availability of a basic innovation. This basic innovation will be the leading principle for further development along the natural trajectory, and the ongoing process of incremental improvements will result in the implementation of a product' [also *Nelson and Winter, 1982*].
3. The Appendix of this article summarises the various surveys that were carried out in the tile cluster of *Karanggeneng.*
4. The inflation rate in Indonesia during the period of study was about ten per cent per year.
5. The production sites of those who stopped producing tiles were sooner or later taken over by others. We do not have exact information on the number of tile producers in the cluster in 1990. The number has however definitely declined as a consequence of urban expansion of the city Boyolali which has caused resettlement of producers. A new count was carried out in August 1993 of which the result will be reported later in this study.
6. This census was part of a research project which specifically aimed at assessing the impact of technological change on female entrepreneurs and workers [*Wahjana, 1994*].
7. The census implied conducting brief interviews with all producers by means of structured questionnaires. Such a research method is less suitable as a means of gaining insight into the nature and development of the relations between tile producers. The 1993 survey of our panel focused more specifically on issues of collaboration among firm especially with regard to innovation adoption.
8. If the entrepreneur is female the dummy value is zero, while for male entrepreneurs it is one.
9. We are aware that this is a rudimentary approach to the importance of social networks, but our data do not allow us to specify the concept further.
10. The panel group includes only three female producers. They are underrepresented in the panel and consequently gender has no significant impact on innovation in the logit analysis with panel data.
11. If a producer considered himself/herself to be a relative of a certain pioneer adopter the dummy score was one, while the score was zero otherwise.
12. When producers sell through middlemen, the dummy score is one, while the score was zero otherwise.
13. The other households were no longer living in Karanggeneng. They were reported to have moved to nearby Boyolali city and Semarang.

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APPENDIX

This article is based on surveys, case studies and repeated observations in Karanggeneng in the period 1987–93. The various surveys that we carried out in the cluster can be summarised as follows:

(a) A group of randomly selected producers was interviewed in 1987, 1990 and 1993. When we carried out our first survey among this panel group, the handpress technology had not yet been introduced in the Karanggeneng cluster. The surveys of the panel in 1990 and 1993 show that the number of adopters gradually increased.

TABLE A1

DEVELOPMENTS IN THE PANEL OF TILE PRODUCERS IN KARANGGENENG

1987	1990	1993	Number of Respondents N=34
Traditional	Traditional	Traditional	15
Traditional	Traditional	Press	8
Traditional	Press	Press	4
Traditional	No tile production	Press	4
Traditional	Traditional	No tile production	2
Traditional	No tile production	No tile production	2

Source: Own survey.

(b) In 1990, we executed another survey among all adopters of the handpress technology at that stage. This survey included some producers who also belong to our panel. They were thus interviewed twice in 1990. The additional survey provided useful information on the processes of collaboration among producers and other actors in the area of innovation adoption.

(c) In 1993, we carried out a *census among all producers* in the cluster. This census allows a comparison of characteristics of adopters and non-adopters. This census included the producers of our panel, who, consequently, were also surveyed twice in 1993.

The main developments among the members of the group of randomly selected producers during our research period are summarised in Table A1. This table shows diversity in the reactions of similar small-scale tile producers to the introduction of new technology. The table shows the gradual diffusion pattern of the handpress technology throughout the years. The original panel consisted of 34 producers. We observe that by 1993 there were 15 producers who continued to manufacture traditional tiles only, while there are also 15 producers who had innovated. Another four producers were no longer making tiles.